Incorporating "The Illuminating Engineer."

Light and Lighting

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The Personal Equation— —and the Human Element

ENGINEERS will always have their difficulties. The problems inherent in their craft include those imposed by that imperfectly understood phenomenon defined by Kipling as "the perversity of inanimate things."

The task of the Illuminating Engineer is yet more complicated in that he has so frequently to cope with the prejudice and perversity of mankind—a prejudice that may be all the more difficult to combat because it is based on honest observation.

Can we believe the evidence of our eyes? Certainly only if interpreted by an enlightened mind and with the reservation that what we see others may not. In this connection the experiments with coloured light, summarised on p.71 are revealing. We are well aware that a small minority of people, more or less "colour-blind," may receive impressions at variance with those of the normal observer. We know, too, that even persons presumed to have normal vision differ much in *the extent* to which they are influenced by such phenomena as glare, changes in the apparent brightness of coloured surfaces (the Purkinje Effect), diminution in perceptive power in twilight, etc.

But in the special case here considered we are up against something much more remarkable—that in any assembly of apparently normal people engaged in viewing objects illuminated by coloured light quite a substantial proportion may form conclusions *exactly the opposite* of those reached by the remainder.

This is neither prejudice nor perversity. It results from a combination of two factors—chromatic aberration, present in all eyes, and the accompanying visual defects ("short sight," "long sight," astigmatism, etc.) present in most eyes in varying degree.

This causes us to reflect—does it not?—on the importance of the human element, which may lead certain people to approve a method of lighting which others condemn, and which at least ensures that illuminating engineering can never be a dead science.

The I.E.S. Annual Meeting

We hope shortly to give a fuller account of the proceedings at the annual general meeting of the Illuminating Engineering Society, which took place in London on May 13. For the moment we merely wish to put on record this event, which proved once more to be very successful, the opportunity of meeting together being much appreciated by members in these difficult times.

The morning was devoted to a conference attended by representatives of local centres, at which knotty points were discussed and measures for their elucidation agreed upon. It is evidence of the keen interest felt in the society's future that all the active centres were represented. The experiment, initiated last year, of holding an informal luncheon at St. Ermin's Hotel was repeated, about 80 members attending. The meal was naturally a simple one and the toast list brief, Mr. Howard Robertson proposing the toast of the I.E.S., to which the president (Professor J. T. MacGregor Morris) replied. It was pleasant to have at the gathering old and eminent members such as Sir Duncan Wilson and Miss Caroline Haslett, who were able to get away for a brief hour from their war-time duties.

At the annual general meeting, which took place in the afternoon at the Institution of Mechanical Engineers, the usual formal business was transacted, well-merited acknowledgment of the services of the president, officers and council during the past session was made, and the revised by-laws were presented by Col. K. Edgcumbe and approved subject to formal ratification at a forthcoming special meeting.

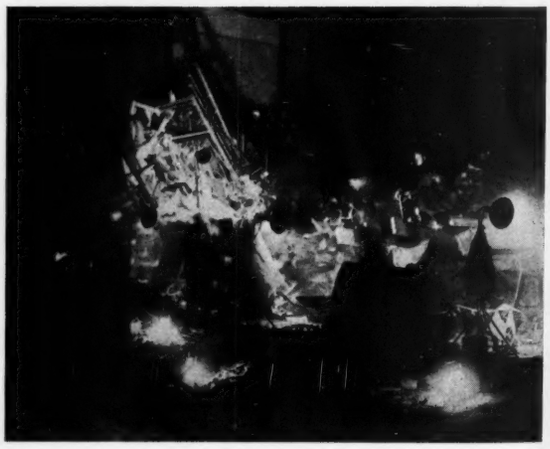
Mr. R. O. Ackerley's address reviewing lighting problems involved in post-war reconstruction was greeted with enthusiasm. The address was based largely on suggestions invited from members of the society, which the author had assembled with considerable skill. It was naturally impossible to discuss these numerous and intricate points in any detail, but comments were made by leading members of the society and architects and other guests present, all of whom agreed on the importance of the subject. The proposals that panels should be formed to study these problems, so that the society would not be caught unprepared when peace arrived, was warmly acclaimed, and the council was requested (nay, commanded !) to get on with the job.

New Members of I.E.S. Council

A new feature this year was the carrying out of a Postal Ballot for members of the I.E.S. Council for the coming session. It was announced at the annual meeting that the elected members were: Mr. T. Catten, Dr. W. M. Hampton, Mr. J. W. Howell, Mr. W. F. Pogson, Mr. J. S. Preston, Mr. E. B. Sawyer, Mr. P. Crawford Sugg, Mr. H. C. Weston, and Dr. W. D. Wright.

Portable Lamps for Rescue Work

Even before the war the inconsistency of aims demanding complete absence of light in the streets, in order to avoid presenting a target, and sufficient light to facilitate rescue work was evident. Subsequent experience has shown that under urgent conditions light must be provided, even at the risk of visibility from above. The chief requirements are that the light should be adequate but not excessive, that its direction should be controlled, and that risks of igniting gas or other inflammable materials should be reduced to a minimum. These conditions have been met by a unit comprising five 12 v., 12 w. electric " bus lamps " mounted in a dispersive reflector protected by wire gauze and supplied by an accumulator giving



10 hours continuous light per charge. In response to urgent demand a unit of this type, mounted on a tripod, was designed by the General Electric Co., Ltd., at short notice. Sets have been distributed to various A.R.P. centres and have since proved invaluable.

The illustration is reproduced from an actual photograph taken entirely by the light of several of these lamps in operation.

X-Ray Analysis in Industry

An opportunity of learning more of this interesting subject will be afforded shortly by the publication of a series of papers invited by Sir Lawrence Bragg, President of the Institute of Physics and a pioneer in this field. The papers will be published by the Institute in two special issues of the Journal of Scientific Instruments, copies of which (price 2s. 8d. each post free) will be obtainable from the Institute of Physics, The University, Reading.

Visibility by White and Coloured Light

In what follows we give a summary of the contribution under the above title, presented by Mr. J. S. Dow at the meeting of the Illuminating Engineering Society held in London on April 8, 1941.

In introducing this subject Mr. Dow recalled the question investigated by expert I.E.S. Committees shortly after the outbreak of war, whether there was any substantial advantage in adopting light of any special colour for general outdoor lighting. Hastily improvised systems of lighting, based on the use of lamps coated with blue lacquer, were then being introduced, and there was an impression that the choice of blue light diminished visibility at a distance. It was soon found, however, that there was no such advantage in this respect as justified the use of blue light on a large scale—especially in view of the loss involved in obtaining pure blue light by a subtractive process, which, in the case of filament lamps operated with filters, might amount to as much as 99 per cent.! Systems of general lighting, such as war-time street lighting, have therefore been based upon the most economical use of white light.

Special Problems.

There is, however, still a possibility that there may be advantages in using light of some particular colour under special conditions. This was not primarily a war-time problem, but had a bearing on general conditions—for example, those met with in street lighting with mercury and sodium lamps.

Mr. Dow recalled that these phenomena were not new, but had been treated in books on physiological optics issued many years ago.

The main factors in the problem appear to be: (1) The Purkinje effect; (2) Selective absorption by the atmosphere; (3) the influence of colour on acuteness of vision; and (4) the influence (if any) of colour on visual ability in other respects, such as speed of perception. To these might be added (5) special circumstances arising from the purpose served by the light provided, which might favour the choice of some particular colour.

The Purkinje Effect.

Mr. Dow then briefly recalled the peculiar behaviour of the eye towards colours in very weak light, known as the "Purkinje Effect," which had been very lucidly explained by Dr. J. W. T. Walsh in a recent contribution to this journal.*

At low illuminations the eye is relatively much more sensitive to the blue end of the spectrum than to the red. At a very low order of illumination the sense of colour is lost. The red sensation then fades out completely (so that red-coloured objects appear black), whilst the blue sensation still persists (blue objects appearing a faint grey). The centre of the eye, however, whilst it still retains sensation, is more sensitive to the red end of the spectrum than to the blue end, whilst for the peripheral region of the retina the reverse is the case.

Selective Absorption by the Atmosphere

Whilst the degree of selection depends greatly on atmospheric conditions, the tendency is for the light of the shorter wave-lengths to be most readily absorbed and scattered by minute particles. This is confirmed by such familiar facts as the red and orange colour of the transmitted light at sunset and the blue luminous haze (due to scattered blue light) which colours distant mountains. Such effects take place through a considerable depth of atmosphere, but must be taken into consideration in assessing the visibility of coloured light when viewed from a distance of some miles.

* "The Reds and the Greens," "Light and Lighting," Oct., 1940, p. 162.

Influence of Colour on Acuteness of Vision

The author discussed this point somewhat fully in a paper read before the Society about twelve years ago.* Attention was then drawn to the effect of the want of achromatism of the human eye. Images of objects illuminated by red and blue light are displaced either side of the focusing position for white light. The influence of this factor varies with different eyes and the nature of their optical effects. But most people seem to find that in the case of distant vision (more than 10 ft. or so) it is difficult to focus on blue light, and correspondingly easy to get a sharp image of the red, whilst for close vision (reading distances or less) the reverse is the case.

Application to Visibility Problems

A series of experiments were shown by Mr. Dow in order to illustrate the bearing of these factors on the visibility of illuminated areas, seen from a distance. Patches of red, white, and pure violet light of equal size, and, at close quarters, of approximately equal brightness, were projected on the screen. It was pointed out that as the distance of the observer was increased the brightness of the red patch became accentuated, and that it could be best seen by direct vision. The brightness of the violet patch was greatly diminished when viewed from the back of the hall by direct vision—in fact, under certain conditions it could be made to disappear when one looked straight at it, but it reappeared in apparently enhanced brightness when it was viewed obliquely, so that the image fell on the peripheral region of the retina.

Much discussion took place in regard to the appearance, from the back of the hall, of a lamp filament viewed through cobalt glass (transmitting deep red and deep blue light). The lecturer anticipated that his own experience—of seeing a central red spot surrounded by a blue haze—would be shared by most other observers, but there was greater diversity of opinion than was expected, and in a number of cases the effect was reversed when observers removed their eyeglasses. The same was broadly true of other experiments showing the comparative sharpness and apparent contrast of objects illuminated by light of various colours—though in this case the majority of the audience seemed to share the view that distinctness in blue and violet light was not good.

The lecturer pointed out the bearing of these various factors on impressions formed of street lighting by means of mercury and sodium vapour lamps. In the case of those persons who found difficulty in focusing distant blue light there was a tendency for the blue element in light from the mercury lamp to spread, causing haziness of outline but an impression of great general brightness, whereas objects illuminated by sodium light appeared much more sharply defined.

Mr. Dow recalled that there was also a secondary effect, the difference in rate of growth of sensations in different regions of the spectrum. It had been claimed that, in the case of sodium lamps, this gave rise to enhanced contrast at low illuminations.

Very Close Vision

In conclusion, Mr. Dow, whilst emphasising that the contribution was intended to deal mainly with distant vision, suggested that there was also room for investigation of the effects of coloured light in the case of objects viewed at "reading distance" or less. His own experience was that the effort of accommodation in such circumstances was least and the definition best with blue light. It was also possible that there might be some inherent advantage in using this part of the spectrum, similar to that recognised to exist in work with the microscope.

* "The Illuminating Engineer," June, 1928, p. 167.

Artificial Daylight for Colour Matching

In this article the author reviews the recently issued British Standard Specification for Artificial Daylight Fittings for Colour Matching (B.S.S. No. 950—1941) and discusses the difference in the demands made by equipment furnishing "sensation daylight" and a quality of light suitable for accurate colour matching.

For many years past so-called "artificial daylight" lamps and fittings have been marketed, and their use for various purposes has been advocated. Some people find that they can work or read more comfortably by a light which resembles daylight in colour, while others find no benefit or even express a preference for what they frequently describe as "a warmer light." The fact seems to be that it is largely a matter of personal preference, and no convincing evidence has ever been adduced in support of the claims which have sometimes been made for the use of artificial daylight for ordinary purposes. Those who prefer such a light do not require anything like an accurate imitation of daylight; something that seems similar to the eye is quite sufficient. In other words, a "sensation daylight" is all that is needed, and this can be provided in many different ways, e.g., by the use of blue glass for the bulb of a tungsten filament lamp, by one of the new fluorescent discharge tubes, etc.

There is, however, quite a different field of use for artificial daylight in which it is necessary to have as close an imitation as possible of real daylight, not only as far as its general appearance to the eye is concerned but also as regards its effect on coloured surfaces. The colour of a fabric, for instance, depends (sometimes very critically) on its power to reflect light in one part of the spectrum much more strongly than light of other wave-lengths. If the light by which it is viewed happens to be seriously deficient in that particular part of the spectrum, of course the colour of the fabric will be altered. An artificial daylight for colour-matching purposes, then, must imitate real daylight as closely as possible *throughout the visible spectrum*.

The British Standard Specification.

For many years artificial daylight fittings have been used for colour matching, but there has, until lately, been little attempt to introduce uniformity of performance among the fittings marketed by various manufacturers. This has been a real drawback, since in several respects there is ample scope for divergence of aim in the design of such fittings. For instance, what is "real daylight"? Is it sunlight or north skylight on an overcast day, or the light from a clear blue sky? When this point has been settled, so that the spectral distribution to be imitated is known, there is the consideration which enters into every specification, viz., that perfection is unattainable in this imperfect world. What tolerances, then, should be allowed so that on the one hand a quite unpractical degree of precision is not demanded, while, on the other hand, the imitation is sufficiently close for the results obtained to be acceptable in practice? It is considerations such as these, no doubt, which led the British Standards Institution to prepare their recently published Specification for Artificial Daylight Fittings for Colour Matching (B.S.S. 950—1941) which was noticed in this journal last month.*

* "Light and Lighting," April, 1941, p. 65.

The Colour of Daylight.

In this specification the form of daylight taken as standard does not reproduce precisely either sunlight or north skylight, but it is a very close approximation to the latter. It possesses the great advantage that it is one of the standard lights adopted for colorimetry by the International Commission on Illumination, and can be fairly readily reproduced at any time in the laboratory. Full details of the way this can be done, using a standard tungsten lamp and a colour filter, are given in an appendix to the Specification. For all practical purposes it may be said that the form of daylight adopted is north skylight on an average day in spring in this country.

The colour of the light given by an artificial daylight fitting must match the standard light within certain limits. The light from the fitting is compared with that of the standard lamp after it has passed through the colour filter, and the voltage on the standard lamp is adjusted until the two lights match in colour to as close an approximation as can be managed. The colour temperature of the lamp-filter combination at this voltage must lie between 6000°K and 7500°K.*

Generally it will be found impossible to obtain an exact colour match, and one of the two lights being compared will appear slightly greener than the other. This defect must not exceed a certain amount, and it is measured by placing a wedge-shaped greenish filter (actually a specified acid solution of nickel sulphate) in the path of the light which appears less green. The wedge is moved across the beam of light, so that the thickness of solution traversed is altered, until a good colour match is obtained. The thickness must then not exceed a certain specified value.

The Spectral Distribution.

The test described above is applied to the artificial daylight taken as a whole, and a different form of test must be used to ensure that the distribution through the visible spectrum, i.e., the colour composition of the light, is a sufficiently accurate imitation of that of the standard daylight. Various methods have been proposed for making this test. The most complete and fundamental is, of course, the determination of the spectral distribution curve of the artificial light, using some form of spectrophotometer. This, however, is laborious and requires rather elaborate apparatus.

The method adopted in the Specification is a compromise between extreme accuracy and ease of application. In effect, the spectrum is divided into nine portions by means of colour filters, which may be described roughly as violet, blue, blue-green, green, yellow-green, yellow, orange, red and deep red respectively.†

The artificial daylight fitting and the standard lamp, with its filter, are mounted on a photometer bench on opposite sides of a photometer head. One of the nine filters is held in front of the observer's eye, and the distance of the standard lamp from the photometer head is adjusted until an equality setting is obtained. This distance is noted, and the process is repeated for each of the other eight filters. The inverse squares of these nine distances give, in effect, the relative amounts of violet, blue, etc., light in the spectrum of the artificial daylight as compared with the standard daylight. For the ideal artificial daylight, therefore, the nine distances would all be exactly the same. The allowable departure from this ideal is laid down in the Specification for each colour separately; it varies somewhat, from about 20 per cent. at the blue to 30 or 40 per cent. in the red part

* The relation between voltage and colour temperature for the combination is obtained by previous standardisation in a laboratory.

† The transmission characteristics of these filters are laid down in an appendix to the Specification.

of the spectrum. This is due to the fact that a given departure from the ideal spectral distribution is more noticeable in the blue than in the red. The Specification concludes with an appendix in which the calculation involved in the application of this test is made clear by means of a worked example.

Commercial Fittings.

There are a number of fittings on the market which will comply with the requirements of the Specification. The majority of these are of the type in which the light from a tungsten filament lamp passes through a colour filter, usually of glass and sometimes made up of two or more components. Of a different type is the carbon dioxide discharge tube in which no colour filter is necessary. The spectrum given by this tube is not continuous, but the lines are so numerous and so distributed throughout the visible range that this source complies quite satisfactorily with the Specification.

The recent development of the fluorescent discharge tube seems to give promise of yet another type, although nothing seems to have been published to show whether or not such a tube can be made to comply with the requirements of the Specification. It might prove necessary to employ a colour filter in conjunction with a lamp of this kind, but even so the efficiency of the combination should be much higher than that of a tungsten lamp used with a filter, for it will be clear that it is fundamentally impossible to avoid a very considerable loss of light in this latter combination. In the B.S. Specification for the "sensation daylight" lamps and fittings (B.S.S. 793—1938) the maximum attainable efficiency with which an effective colour temperature of 5500°K can be produced is given as 28.4 per cent. For a colour temperature of 6500°K, therefore, the efficiency cannot possibly exceed about 25 per cent. and must, in practice, be noticeably less. In most cases, however, where accurate colour-matching is required, the (power) efficiency of the light source is comparatively unimportant; it would only become a serious matter if, for any reason, a considerable area had to be lighted to a high intensity with an accurate reproduction of daylight.

Post-War Applications of Colour and Display Lighting

by R. GILLESPIE WILLIAMS

A Lecture given to the Nottingham Sub-Centre of the Illuminating Engineering Society on Friday, March 28, 1941.

The lecture and demonstrations enlarged on the use of light, not only as a means of dispelling darkness, but as an end in itself. Form besides function, and quality rather than quantity, were considered. The lecturer predicted that an era will shortly commence in which lighting will be employed, not only to reveal beauty but to impart beauty.

The production of colours from three primary hues was considered, and the factors of merging, contrasts, relative intensities and areas, and composition were examined. The applications which were considered were dealt with under two headings; namely, (a) Static Colour Compositions, and (b) New Art of Animated Colour.

It was shown that colour-tinted light, employed for the illumination of coloured objects, can be used to heighten and strengthen colour tones in objects and to accentuate and reveal form and outline. When dealing with white or neutral objects, colour hues of a vivid and striking nature can be made to provide colour compositions and harmonies satisfying in themselves.

Throughout the ages, the art of employing colour has been very largely based on the creation of static colour compositions, but with the new art of colour lighting we have a new field of animated colour to explore, whereby we can create colour compositions in which some, or all, of the factors can be easily changed through variations in the lighting. It was shown that animated colour can impart a variety of interests and meanings to basic design and forms, and can be allied to varying activities and purposes. Demonstrations were also given of colour as the visual expression of sound, and as a medium for the expression of thought. Some startling effects for display and advertising purposes were also demonstrated.

One of the main problems in practice is to provide methods of control which will allow the potentialities of the installation to be utilised by operators who may lack art and skill in the subject. The control of colour lighting must be based on genuine artistic and scientific fundamentals, and not represent a form of quackery. Many types of mechanism were discussed, including controllers for use when no operator is needed or available. The light sources, colour filters, and reflectors, etc., required in different types of equipment were considered, and problems of ventilation, diffusion, current consumption, etc., examined.

By means of lantern slides the lecturer gave particulars of numerous installations in cinemas, theatres, public halls, etc., and it was seen that many of these were not only involved in character, but had exercised a very decided influence on the decorative treatment and, in many cases, the actual design of the building. A new technique in the design of building frontages to suit night illumination was discussed, and changing colour schemes to attract attention and renew interest were suggested. It was seen that there is a large field for the use of colour lighting for outside display lighting, and for the illumination of curtains, bathing pools, and terraces at night.

The post-war period will provide a large field for the use of colour lighting in shop windows, and the subject of display backgrounds and different forms of effect and functional lighting were demonstrated. Fluorescence can be employed to enrich tints, reveal lighting effects in signs, etc. In the near future a greater use will also be made of colour lighting in shop interiors, not only for the lighting of show cases and displays, but for the actual decorative treatment of the surroundings.

Colour photography provides a new field for lighting, and a greater use is likely to be made of coloured rather than white, light in order to get both accuracy and effect in photographic views. A new technique and colour treatment for film work is likely to evolve.

The demonstrations which accompanied the lecture by Mr. R. Gillespie Williams included items in which assistance was provided by two charming ladies. A radiogram was provided for music, and three dimensional sceneries, together with special draperies were fitted up for the occasion.

War-Time Photometry

Summary of an address delivered by Professor J. T. MacGregor-Morris to the I.E.S. Midland Centre in Birmingham on April 25.

The I.E.S. Midland Centre is reaping the reward of its enterprising policy of resuming its interrupted programme of meetings during the early summer, when abundant daylight renders the holding of evening meetings much easier. In what follows we give a brief account of the very successful meeting held last month. We understand that Mr. E. W. Murray, who will discuss a variety of problems met with in his experience of A.R.P. lighting, is to be the next lecturer.

The meeting on April 25 was held in the Birmingham Municipal Technical College, under the chairmanship of Dr. W. M. Hampton. After the general business of the meeting the chairman called upon the President of the Society, Professor J. T. MacGregor-Morris, to address the members.

The President began by congratulating the members on carrying on the work in spite of difficulties, and wishes them continued success in their efforts. He then turned to the subject of his address, which was "War-time Photometry." He recalled how a need in war-time photometry was met during the 1914-18 war by a committee formed chiefly of members of the Illuminating Engineering Society. After some preliminary measurements, the major part of the work was carried out at Stonebridge Park during the early hours of the morning. He showed by slides and explained the operation of the photometer, which was developed specially for the measurement of the illumination yielded by star shells and parachute flares.

The lecturer then turned to developments during the present war involving the study of the visibility of objects at very low illuminations. Through the kindness of Mr. Howard Long and the local hon. secretary, Mr. Allderidge, arrangements had been made so that the current operating the 500-watt lamp in the lantern could be reduced gradually to such a value that no light whatever was emitted. (As it was daylight outside this, incidentally, showed up the defects in the darkening of the lecture theatre!) With considerable care the strong illumination was reduced to about 0.0001 ft.c. on the lower part of the blackboard. He then repeated an experiment, shown by Mr. Dow at a recent meeting in London, illustrating the fact that at very low illuminations the apparent brightness of an object depended upon its size. Mr. Dow had used black and grey discs placed on a large white background. In the present case the arrangement was reversed—i.e., white discs respectively 2 ft., 1 ft., and 6 in. in diameter were affixed to a large blackboard at suitable distances apart. The illumination was first fixed at 0.002 ft.c., as determined by a Holophane lumeter gauge, and was later reduced to 0.0002 ft.c. At such a low value of illumination the majority of the audience could only say that in the case of the 6-in. disc "something" was there, but could not state its precise form, while the 2-ft. disc was quite definite in form. As the illumination was raised, of course, all three discs came into view and appeared equally well defined.

Professor MacGregor-Morris then showed a slide of the graph that Dr. Walsh had given in London showing the effect of reduction of illumination on the possible accuracy of photometric measurements. Summing up, the lecturer stated that (1) if low illuminations are used, then we require large fields for discrimination of form, and (2) as the illumination is reduced the possible accuracy of measurement diminishes—and this quite apart from further difficulties due to colour difference.

The remaining portion of the lecture was devoted to a description of photometric apparatus which has been developed in consequence of war-time conditions. The speaker acknowledged his debt to Colonel Kenelm Edgcumbe and Mr. E. W. Murray for the loan of specimens of apparatus for determining the effectiveness of motor-car headlight screens, checking the brightness of black-out signs, and to Dr. S. English for the Holophane light gauge for gauging low illuminations.

The President's address was heard with keen interest, and at the conclusion of the lecture there was a really good discussion.

A New Field of Illuminating Engineering

In recent years the work of the illuminating engineer has been extended to embrace the utilisation of ultra-violet radiation, particularly in the production of fluorescent effects and in the development of new types of lamp.

Another new field has now been opened up by the application of short wavelength radiation to the control of bacteria, and much development work has been carried out in the U.S.A.

It has been established that many forms of bacteria, including air-borne varieties, can be killed by short wavelength ultra-violet radiation. The lethal action of the radiation is a maximum at about 2660Å.

Porter and Neidhardt (G.E. Review, May, 1940) have described lamps which emit 95 per cent. of their radiation at 2537Å. They consist of tubes containing a mixture of inert gases and mercury vapour at low pressure, through which a discharge of low current density is passed, the tube itself being made of a special U.V. transmitting glass. Where it is necessary to control, or redistribute, the radiation, aluminium reflectors can be efficiently employed as these have a high reflection factor for radiation of low wavelength.

Rentschler (Illuminating Engineering, Dec., 1940) has outlined some situations where the lamps are being successfully applied. A very important application has resulted from research carried out by Dr. Daryl Hart, of Duke University. One of the major problems in surgical work is to control the bacteria introduced into the air by the surgical staff in proximity to the operating table, as such bacteria are frequently responsible for many of the affections which occur after major operations. Dr. Hart has found that the incidence of such infection can be controlled by installing a series of bactericidal lamps round the operating site, so providing, in effect, "curtains" of sterilising radiation.

This principle has been extended to other situations, similar "curtains" being provided at the entrance to hospital wards, and, in some cases, between adjacent beds. The installation of these lamps at suitable points in factories might conceivably result in a diminution of infection among the employees.

The radiation from these lamps is also effective in limiting the growth of mould and bacteria in some perishable foodstuffs of which meat and bread are two of the most important. Although it is frequently difficult to ensure that the radiation reaches every surface involved, it is claimed that specially designed installations have proved to be very successful, and a most valuable adjunct to the more usual methods of preservation.

In view of the urgent problem of preventing infection in large air-raid shelters, it is interesting to note that these lamps have been installed in the ducts of air-conditioning systems, and that tests have shown that a single 15-watt lamp in a non-reflecting duct will kill approximately 97 per cent. of the bacteria in air passing through a duct at the rate of 200 cubic feet per minute.

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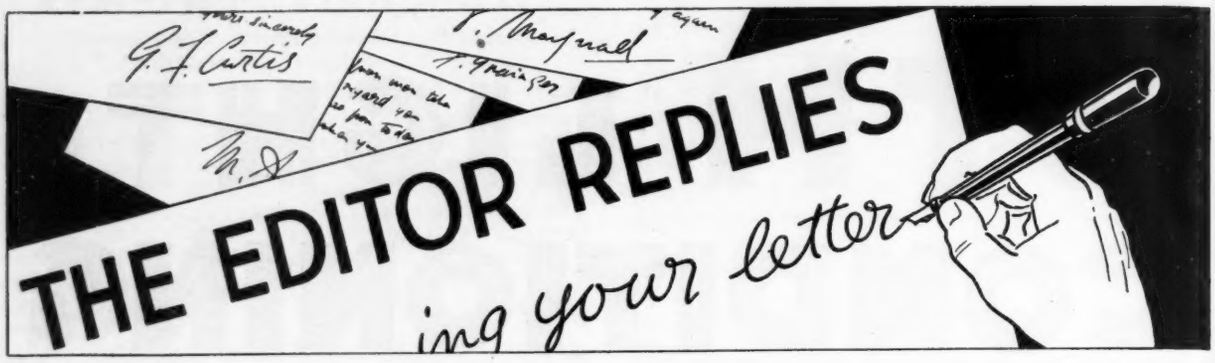

The notes on **Lighting Fittings for Providing Low Illumination** in our last issue (April, 1941, p. 54) have brought me some comments, some from those who scout the idea that fittings furnishing such low illuminations can possibly give rise to glare, others from people who contend that, with the dark adapted eye, the exposure of any light source of normal brightness within the field of view must cause some degree of dazzle.

I suspect the divergence in view has two main explanations—differences in interpretation of "glare," and differences in personal sensitiveness.

Naturally, exposure of these weak lights does not cause paralysing glare in the same sense as do powerful motor-car headlights. But they may, nevertheless, depress sensitiveness of vision, rendering it difficult to see objects of small contrast.

There is no doubt that **sensitiveness,** especially to **"discomfort glare,"** varies greatly . I would not say myself that the war-time street lighting fittings caused appreciable glare (though, even so, I would personally prefer that the source was completely hidden), but I am conscious of a little glare from the fittings furnishing 0.002 ft.c., and I think there is common consent that the original (widely spaced) fitting for 0.02 ft.c. was definitely troublesome in this respect.

Sensitiveness to glare is, I believe, partly a function of age. One becomes more conscious of glare as one grows older. But it also depends much on the condition of the eye, which, in turn, depends on general health. Eyes which tend to be catarrhal or slightly inflamed (possibly due to chronic digestive trouble) are unduly sensitive. On the other hand, it may be possible to become insensitive to glare through occupation. Attendants on furnaces doubtless become accustomed to bright light, and I have heard instances of sea captains, whose eyes had been toughened by long exposure to sunlight on the ocean, who were genuinely unconscious that glare existed.

This leads me to refer to another quality of vision, **ability to see easily,** like a cat, **in very weak light.** Dr. Wright has reported considerable differences in the powers of otherwise normal people in this respect. I have been asked whether it is true that night-vision can be improved by "stoking up" with the right vitamins. This is a question for physiologists to answer. For my part I should doubt very much whether any remarkable powers could be acquired in this way—though the converse effect, deficiency in twilight vision when essential vitamins are withheld, seems easy to understand. Such occupations as those noted above, which produce insensitiveness to glare, must surely be unfavourable to sensitive night vision. In this case, also age and condition of general health are doubtless important factors. In the case of all processes involving keen vision in very, very weak light, such as those undertaken by **pilots concentrating on night-flying**, the fundamental conditions are firstly to select operators with good natural powers of night observation, and next to ensure that ample time is allowed for dark-adaptation before such powers are exercised.

The lot of the motorist in war time is a difficult one. There is no need to dwell upon the hazards of night driving in present circumstances, but a correspondent reminds me that there are also hazards by day. One of these is the danger of over-running **road traffic signals,** which in their present reduced form (possibly weakened by encrustations of grime) are most difficult to recognise. It is not too much to say that in full sunlight it is sometimes impossible to see whether they are "on" or "off." There is, I believe, in existence an arrangement permitting the minute luminous cross to be replaced by a larger area during daylight—but authorities rarely seem to avail themselves of this concession.

Mr. F. A. Rogers, the secretary of The Electric Light Fittings Association, has written in regard to our recent note on the **Purchase Tax and Lighting Fittings** (March, 1941, p. 48). He states that fittings specifically designed for industrial purposes and normally so catalogued are accepted as "essential." Such fittings are defined in the Electrical Fair Trading Policy [Schedule 3, Category (1)] and in H.M. Customs printed notice No. 78. The list given in this notice has been adopted by H.M. Customs and Excise in accordance with the suggestions from E.L.F.A., whose guidance and assistance in connection with this problem is freely given to the fittings trade.

The expression **"Intensity."**—An argument put to me in favour of the use of this term in a general sense is that scientists have *no right* to seize upon familiar words in the English language and assign to them limited and specialised significance. Unfortunately, this is just what scientists and technicians persist in doing. My inclination towards the general use of "intensity" to indicate "strength," as contrasted with quality, is based on a primary need. We *want* the word in this sense.

Obituary

We learn with great regret of the death of Mr. R. E. Battersby, chief engineer to Messrs. Lee, Beesley and Co., Ltd., of Coventry, and their representative as I.E.S. sustaining members. Mr. Battersby lost his life through enemy action whilst engaged on fire-fighting duties.

Literature on Lighting

(Abstracts of Recent Articles on Illumination and Photometry in the Technical Press)

(Continued from page 65, April, 1941)

I.—RADIATION AND GENERAL PHYSICS.

88. The Distribution of Energy in the Visible Spectrum of Daylight.

A. H. Taylor and G. P. Kerr. J. Op. Soc. Amer., Vol. 31, No. 1, pp. 3-8, January, 1941.

A series of curves of spectral energy distribution in sunlight and daylight under various conditions is reproduced. Variations in colour temperature are discussed in relation to the choice of a standard for colour matching. A. E. S.

89. Colour Vision and the Automatic Nervous System.

S. V. Kravkov. J. Op. Soc. Amer., Vol. 31, No. 4, pp. 335-337, April, 1941.

Experiments on the effect of the installation of adrenalin and pilocarpin on the colour sensitivity of the eye lead to results which can be made to account for other fluctuations in colour sensitivity. A. E. S.

90. The Photon Theory of Optical Resolving Power.

B. P. Ramsay, E. L. Cleveland, and O. T. Koppius. J. Op. Soc. Amer., Vol. 31, No. 4, pp. 296-300, April, 1941.

Follows on a previous paper by the same authors (Ibid. 31, 202, 1941), and brings the photon theory of spectroscopic resolution into line with Rayleigh's formula. A. E. S.

91. The Geometry of Stereoscopic Projection.

J. T. Rule. J. Op. Soc. Amer., Vol. 31, No. 4, pp. 325-334, April, 1941.

Correlates previous knowledge on stereoscopic projection and gives some new experimental data on the relation of depth and screen size. The degree of distortion which an audience will tolerate is discussed. A. E. S.

92. The Shape of Stereoscopic Images.

J. T. Rule. J. Op. Soc. Amer., Vol. 31, No. 2, pp. 124-129, February, 1941.

Gives a graphical method of projecting any object plan into the resultant image plan when the conditions of photography and projection are known, and proposes further study on the psychological interpretation of images with their shapes, and hence on the degree of variation permissible without annoyance to the audience. A. E. S.

93. The Effect of the Size of the Particle on the Intensity of Fluorescence of a Phosphor.

M. S. Oldham and William Kunierth. J. Op. Soc. Amer., Vol. 31, No. 2, pp. 102-104, February, 1941.

Within the range of sizes used, the smaller the particle the greater is the intensity of fluorescence, indicating that the phenomenon takes place on the surface. A. E. S.

II.—PHOTOMETRY.

94. A New Transmission Photometer.

Anon. Elect., 126, p. 245, April 25, 1941.

A description is given of a new photometer designed to measure densities on photographic plates. C. A. M.

95. A Footcandle-Hour Integrator for Daylight.

A. H. Taylor. J. Op. Soc. Amer., Vol. 31, No. 2, pp. 105-106, February, 1941.

An instrument has been specially developed for integrating exposures to daylight over a period of time, using a photo-tube with a special filter and an electronic integrator. A. E. S.

96. Construction and Test of a Goniophotometer.

Parry Moon and Jacques Laurence. J. Op. Soc. Amer., Vol. 31, No. 2, pp. 130-139, February, 1941.

A photoelectric instrument is described which is suitable for absolute measurements of reflection factor for specular or matt samples, or with samples exhibiting mixed reflection. A. E. S.

97. A New Non-Recording Densitometer.

W. S. Baird. J. Op. Soc. Amer., Vol. 31, No. 2, pp. 179-180, February, 1941.

Describes a densitometer incorporating a stable amplifier, acting as a null indicator in a balanced photo-electric circuit. A. E. S.

98. A New Projection Comparator-Densitometer.

H. W. Dietert and J. Schuch. J. Op. Soc. Amer., Vol. 31, pp. 54-57, January, 1941.

Describes an apparatus which is fast in operation and enables transmission measurements to be made on any spectral line accurate to better than one per cent. A. E. S.

III.—SOURCES OF LIGHT.

Combined Infra-Red and Ultra-Violet Lamp.

Anon. The Electrical Times, Vol. 99, No. 2580, April 3, 1941.

A unit combining both ultra-violet and infra-red sources for therapeutic work is described. W. E. H.

Fluorescent Lamps.

Anon. Elect., 126, p. 242, April 25, 1941.

A review is given of a year's experience in installations of factory lighting, using 5 ft. 80w. fluorescent lamps. C. A. M.

IV.—LIGHTING EQUIPMENT.

99. Transmission of Artificial Light.

J. B. Harris. Electrician, 126, p. 231-233, April 18, 1941.

A detailed review is given of the characteristics of various types of diffusing media. C. A. M.

100. The Heating of Factory and Office Lighting Fittings and their Connecting Leads.

H. G. Taylor, W. Lethersich, and P. D. Morgan. Beama Journal, 48, pp. 41-44, March, 1941.

A third instalment is given of the results obtained by the B.E.A.I.R.A. on the heating of lighting fittings and their connecting leads. C. A. M.

101. Effect of Residual Colour on Consumer Acceptance of Porcelain Enamel Whites.

John W. Iliff. American Ceramic Society, Vol. 24, No. 3, March, 1941.

Reflection factors of porcelain enamels as determined by reflectometer measurement sometimes show values in disagreement with visual results. It was found that the residual colour in the enamel had an important effect on the apparent whiteness, those enamels containing a residue of blue, giving the appearance of greatest whiteness, up to 6 per cent. of residual colour. W. E. H.

102. Factors Affecting Reflectance.

Clark Hutchison and F. W. Nelson. American Ceramic Society, Vol. 24, No. 3, March, 1941.

The factors affecting the reflection factors of different enamels have been studied. An increase in reflection factor is obtained by fine grinding, the increase depending on the combination of frit and spacifier. The clay used in the mill addition also affects the reflectivity of the enamels. W. E. H.

103. Chemical Methods for increasing the Transparency of Glass Surfaces.

Frank L. Jones and Howard J. Homer. J. Op. Soc., Amer., Vol. 31, No. 1, pp. 34-37, January, 1941.

Valuable increases in light transmission of optical systems can be obtained by forming surface films of low refractive index, and durability can be increased by certain baking operations. A. E. S.

104. Optical Reflection Factors of Acoustical Materials.

Parry Moon. J. Op. Soc. Amer., Vol. 31, No. 4, pp. 317-324, April, 1941.

Reflection factors and trichromatic coefficients are given for 100 samples of acoustical materials, to light from sources ranging in colour temperature from 2,000 to 10,000°K. The properties of these materials when exposed to dust are discussed. A. E. S.

V.—APPLICATIONS OF LIGHT.

105. Calculation of the Light Distribution in Light Wells.

Walter T. White. J. Op. Soc. Amer., Vol. 31, No. 4, pp. 308-317, April, 1941.

The integral equation for the brightnesses of the walls of light wells of certain dimension ratios are calculated by numerical solutions. A. E. S.

106. Interreflections in Light Wells.

Parry Moon. J. Op. Soc. Amer., Vol. 31, No. 4, pp. 301-308, April, 1941.

Expressions are given for the light distributions in light wells having various dimensions and reflection factors for sides and bottom. Experimental confirmation is given. A. E. S.

107. War-time Bollard Lighting.

Anon. Elec. Times, Vol. 99, No. 2581, April 10, 1941.

A war-time lighting unit for mounting on a bollard is described. Light from an inverted lamp falls on an over-reflector built up of eleven reflecting surfaces. Five of these surfaces are designed to spread the light over a wide area while the others provide local light. The resulting distribution is claimed to be very uniform. W. E. H.

Stage Lighting for the San Carlos Theatre, Lisbon

The award to a British firm (The Strand Electric Company, Ltd.) of a contract for the stage lighting of the famous San Carlos Theatre in Lisbon—the Portuguese State Opera House—and its execution in spite of the hazards of war, was the subject of some comment in the "Daily Sketch" some months ago. Although perhaps a little belated, the story of this event, with which two members of the Illuminating Engineering Society, Mr. L. G. Applebee and Mr. F. P. Bentham, were closely concerned, is still worth telling.

The story opens with the award of this £10,000 contract in January, 1940, in competition with French, German, and Italian firms, some of whom predicted that the goods would never be delivered! They were wrong, however. Mr. Applebee, Mr. Bentham, and others made the journey to Lisbon via France and Spain. Details were settled by consultation (through an interpreter) on the spot, and the apparatus was duly prepared for delivery.

Then the difficulties began. All the machinery was awaiting shipment in a warehouse which was destroyed by hostile action during the raids of September. By a miracle the crates containing the equipment survived, but they had to be transferred to Liverpool for final dispatch to Lisbon. It had been intended to send four engineers to oversee the work, but it was discovered that there was a waiting list of 700 for the air journey to Lisbon. The problem was finally solved through the kindness of the Portuguese Ambassador in London, who placed two seats at the disposal of the firm. Mr. Bentham and Mr. Pepworth accordingly travelled by air to Lisbon, where they were followed by the equipment.

Some sensation was caused by the passage through the streets of the city of some sixty cases bearing the stencilled motto, "Britain Delivers the Goods!" and their arrival at the theatre, where, incidentally, other difficulties arose. Not the least of these was the fact that some of the largest cases would not pass through the doorway of the theatre. Concrete and stone steps had to be removed with pickaxes. At this time even the stage floor was not complete. The A.C. supply, on which the operation of the console depended, was only connected on the Tuesday before the Gala Opening Night, and even thereafter was only available intermittently. For this and other reasons no lighting rehearsal was possible. Yet "everything was all right on the night." The lighting effects excited general admiration, and the Prime Minister, Dr. Salazar, in conveying his compliments, remarked on the resemblance of the artificial dawn to the dawns he had witnessed from his own cottage at Coinbra—a remark which gratified Mr. Bentham, as he had taken great trouble to study the Lisbon sky, which in colours differs considerably from the sky in England.

Incidentally, it may be mentioned that Mr. Applebee and his colleagues, in the course of their journey, also visited Oporto, where a lighting scheme for an enormous circus was prepared. We understand that this order, too, has since materialised.

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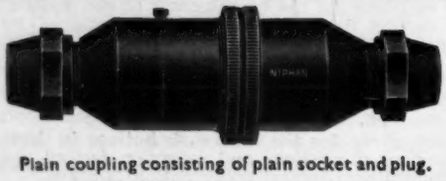
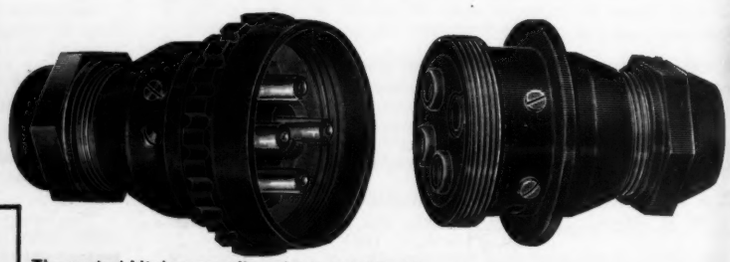


Plain coupling consisting of plain socket and plug.



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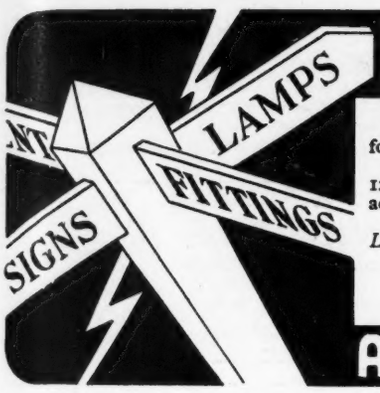

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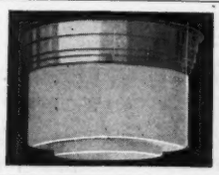

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